Aircraft Landing Gear

EXCERPT of Full Report
FOR PROMOTIONAL PURPOSES ONLY

Aircraft Landing Gear Segmentation

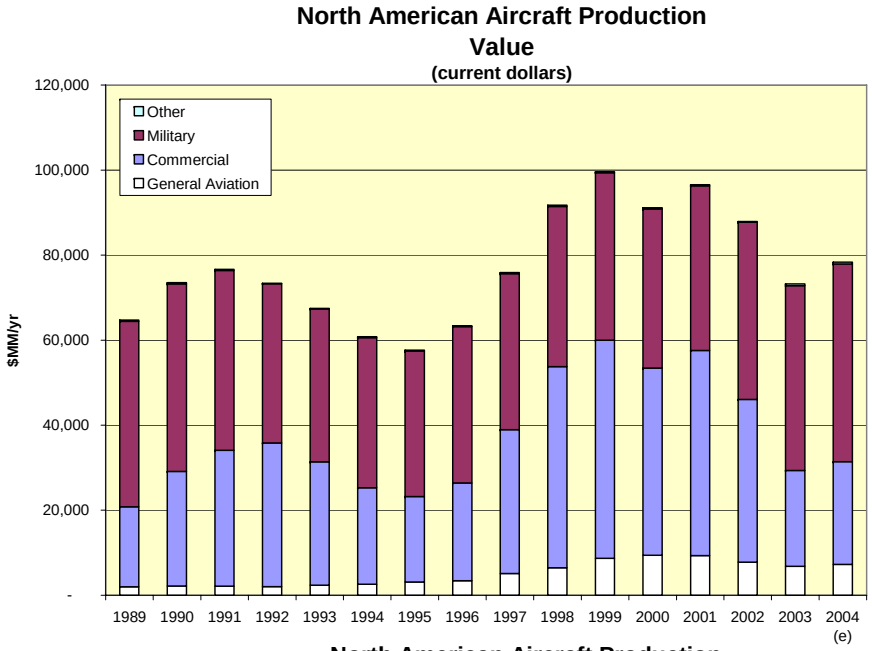
Segment	OEM % of Total Value Opportunity (2004)	Aftermarket* % of Total Value Opportunity (2004 est.)	Applications
Commercial	30	50	Wide-body, single-aisle, regional jets for passenger and cargo
Military	60	40	Fighters, bombers, tankers, cargo
General Aviation	10	10	Privately-owned aircraft - Corporate/business jets, personal
Total	100	100	
***Note: Most landing gear OEMs also provide service contracts to aircraft owners, particularly the airlines**			

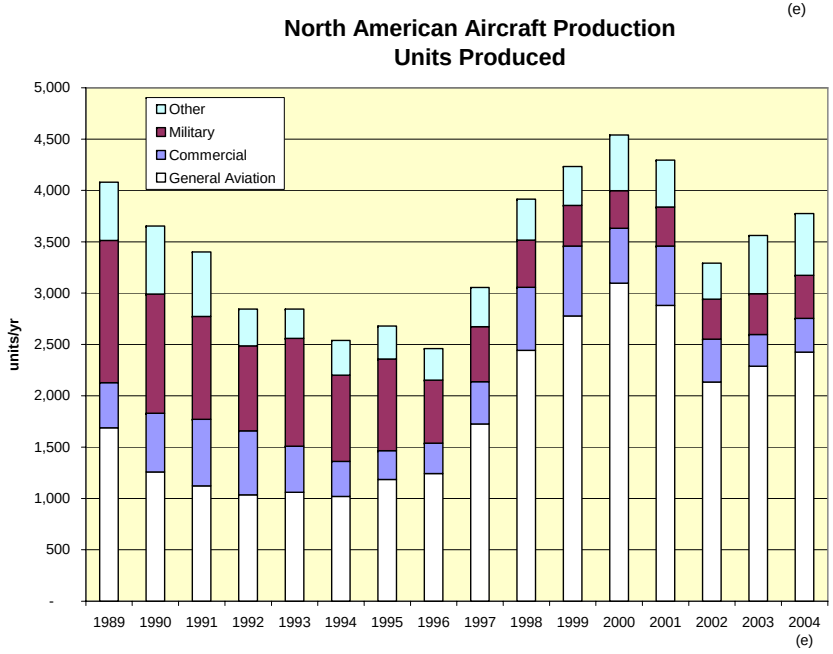
Landing Gear Examples

Photos from Goodrich Landing Systems

Aircraft Segmentation

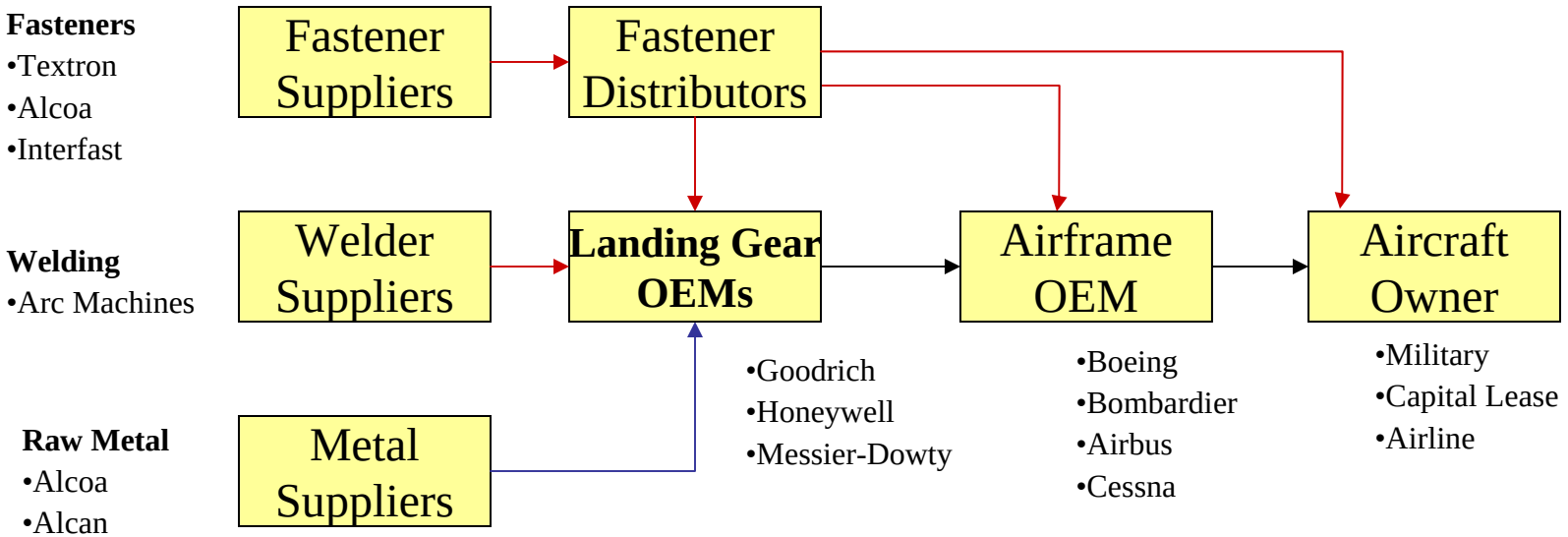
- Overall North America OEM aerospace aircraft industry is $80 billion (aircraft frames) in 2004
- Segments are
  - Commercial
  - General Aviation
  - Military
  - Other
- General Aviation dominates units, but Military currently dominates value
- Industry demand generally follows the economic cycle but is exaggerated
- Commercial production is generally the most cyclical
- Landing systems are valued at $1.1 billion





Aircraft Landing Gear Value Chain

Note: Most fasteners used in landing gear are OEM proprietary



Industry Organizations

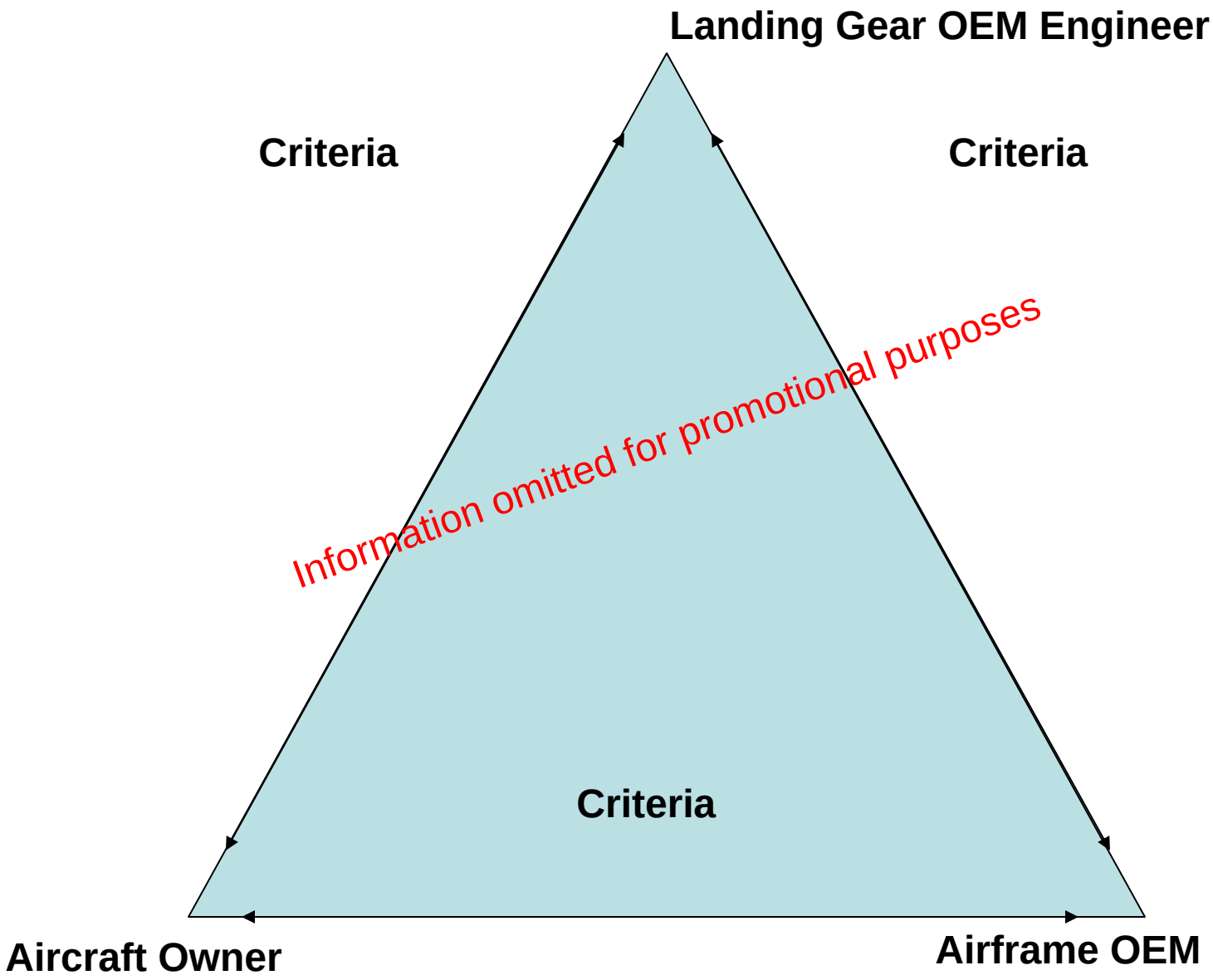
FAA – Federal Aviation Administration

SAE – Society of Automotive Engineers

EASA (formerly JAA) – European Aviation Safety Agency

-flow of fasteners and other components
-flow of non-fabricated metal
-flow of fabricated metal

Fastening Decision Making Process



Decision Roles and Responsibilities

- **Landing Gear Engineer** – responsible for designs including fastener design, fastener engineering and material selection. Landing Gear Engineer must accommodate the requirements of the airframe and engineer within industry and regulatory guidelines. Nearly all fasteners are Landing Gear OEM proprietary design (i.e. little use of industry standard fasteners).
- **Airframe OEM Engineer** – responsible for performance specification and design impact on airframe. Also responsible for aftermarket criteria such as maintenance and service costs
- **Aircraft Owner** – responsible for performance and maintenance of landing gear in the aftermarket. Aftermarket maintenance is often handled under service contracts by the original Landing Gear OEM.

Performance Requirement and Test Methods

The performance and materials specifications for nearly all aircraft designs, regardless of airframe manufacturer, are rooted in three sets of specifications

- Military Specification
- Boeing Standards
- Lockheed Standards

In addition, the Federal Aviation Administration (FAA) has certain regulations that may apply to component design including the use of fastener method

Performance Requirement and Test Methods

Requirement	Point in Value Chain	Test Method (incl Failure Test)	Value	Liability/ Warranty Exposure	Service Life
Drop test	Landing Gear OEM				
Skydrol resistance	All				
Ultimate load analysis	Landing Gear and Airframe OEM				
Fatigue analysis	Landing Gear and Airframe OEM				
Stress analysis	Landing Gear and Airframe OEM				
Load conditions	All				

Unmet Customer Needs

Unmet Need	Description and Point in Value Chain	Opportunities for Adhesives
Lower aircraft weight		Adhesives are perceived to offer lighter weight than mechanical fasteners and also enable lighter materials such as composites
Lower lifetime costs / service costs		
Higher temperature performance		
Increasing use of composites	Composites are being used or considered as replacements for metal for nearly all components including landing gear	

Industry Drivers

Driver	Description	Impact on Fastener Demand and Type
Passenger miles /cargo miles	The major driver for new aircraft is the demand for passenger travel and cargo shipments, both of which show historical growth of 5-7%/yr. However, aircraft builds tend to be much more cyclical than the demand for miles	Demand for fasteners is directly related to demand for new aircraft. Aftermarket demand is also directly related to passenger/cargo miles

Industry Trends

Trend	Description	Impact on Fastening
Changing substrates	Increasing use of composites is driving the entire value chain to new designs and manufacturing processes	Fastening of composites poses significant technical challenges for airframe makers due to limitations in the use of mechanical fasteners - load spreading - fatigue resistance

Major Fastener Design Criteria

Criteria	Importance/ Performance	Impact on Use of Adhesives	Switching Cost/Time and Other Considerations
Shear loading	High	Negative	Very high testing and engineering costs (<$1MM) / switching time could be 3-20 years

Segment Perception of Adhesives

Data omitted for promotional purposes

Role of CAD/CAM

Data omitted for promotional purposes

How is Knowledge of Fastening Techniques Disseminated?

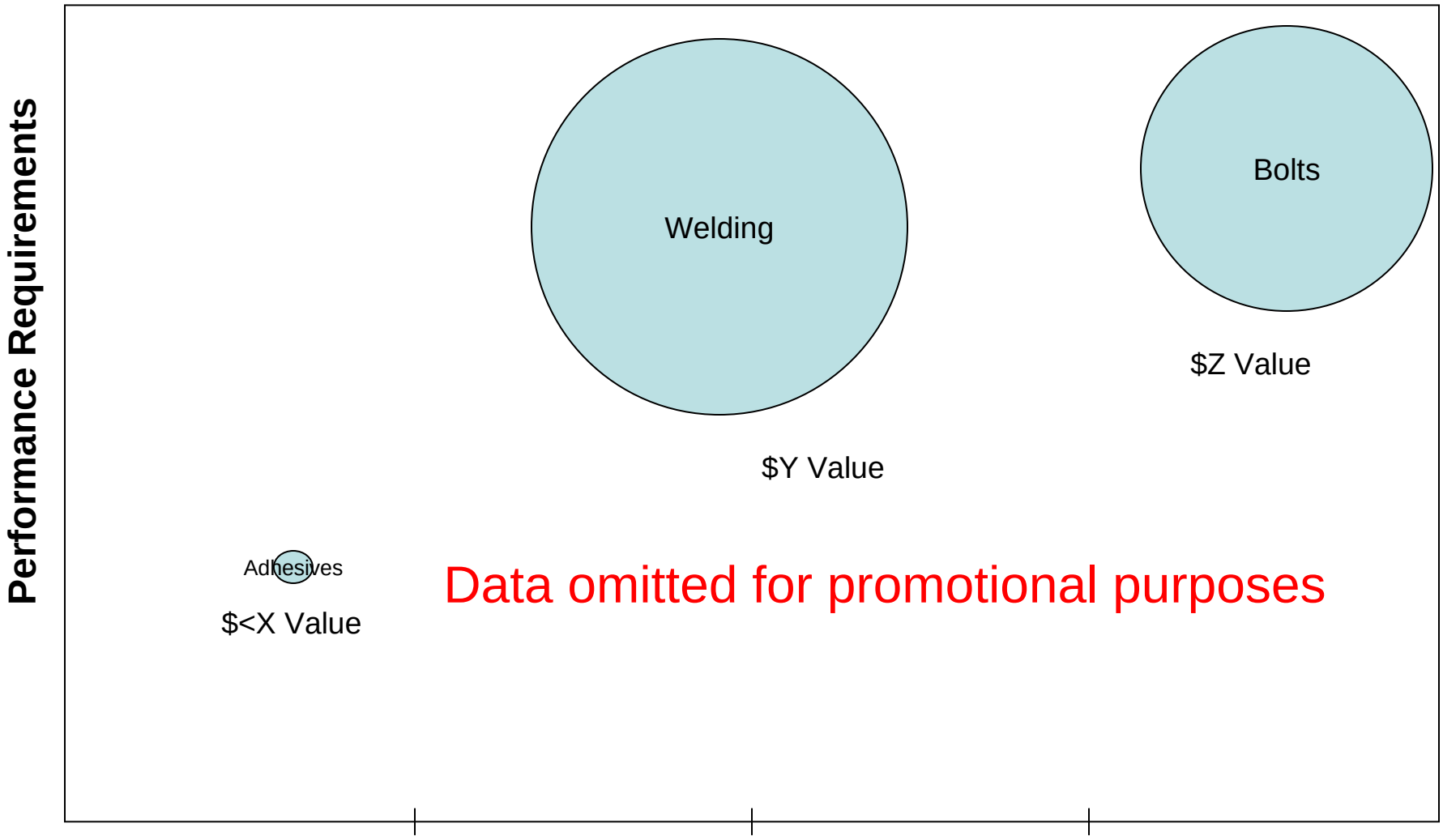
Data omitted for promotional purposes

Validation of Focus Group Findings

Data omitted for promotional purposes

Segment Fastening Cost Model

Value of Incumbent Fasteners



*For adhesives this cost is for each discrete drop or bead, for welding the cost is per inch of weld

Segment Strategy

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